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March 4, 2015

VIA HAND DELIVERY

Bruce Jacobs, Esq.
Chief, Spectrum Enforcement Division
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

RE: ***Interference to WABC-TV by out-of-band emission from Verizon Wireless AWS operations***

Dear. Mr. Jacobs:

Pursuant to Sections 1.711, 1.716, and 1.717 of the rules of the Federal Communications Commission (the "Commission" or "FCC") and Sections 332(c)(1)(A) and 208(a) of the Communications Act, the American Broadcasting Companies, Inc. ("ABC"), licensee of station WABC-TV, New York, New York ("WABC"), by its attorneys, hereby files the attached informal complaint ("Complaint") against Cellco Partnership dba Verizon Wireless ("Verizon"). As demonstrated in the Complaint, Verizon has failed, and continues to fail, to satisfy its obligations under Section 27.1133 of the Commission's rules to protect WABC's electronic news gathering ("ENG") operations in the 2025-2110 MHz band from out-of-band emissions from Verizon's Advanced Wireless Service operations in the A and B frequency blocks (2110-2130 MHz) throughout the New York metropolitan area. Consequently, WABC has been forced to endure substantial interference from Verizon to its ENG operations since September 2013 while Verizon has done little to mitigate this interference.

Please do not hesitate to contact the undersigned with any questions regarding this matter.

Sincerely,

Tom W. Davidson

Tom W. Davidson, Esq.

Attachments

cc: Susan Fox, Esq.
Mr. Steve Maguire
Mr. Scott Semone
Mr. Robert Weller

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
Informal Complaint of American Broadcasting Companies, Inc. Against Cellco Partnership dba Verizon Wireless For Violation of 47 C.F.R. § 27.1133	)	FCC File No. _____

Informal Complaint against Cellco Partnership dba Verizon Wireless

Pursuant to Sections 1.711, 1.716, and 1.717 of the rules of the Federal Communications Commission (the "Commission" or "FCC") and Sections 332(c)(1)(A) and 208(a) of the Communications Act, the American Broadcasting Companies, Inc. ("ABC"), licensee of station WABC-TV, New York, New York ("WABC"),[1] by its attorneys, hereby files this informal complaint against Cellco Partnership dba Verizon Wireless ("Verizon").[2] As demonstrated herein, Verizon has failed, and continues to fail, to satisfy its obligations under Section 27.1133 of the Commission's rules to protect WABC's electronic news gathering ("ENG") operations in the 2025-2110 MHz band from out-of-band emissions ("OOBE") from Verizon's Advanced Wireless Service ("AWS") operations in the A and B frequency blocks (2110-2130 MHz) throughout the New York metropolitan area. Furthermore, Verizon has repeatedly failed to contact WABC and coordinate its AWS operations prior to initiation of its AWS service in contravention of Section 27.1133 of the FCC's rules. Consequently, WABC has been forced to endure substantial interference from Verizon to its ENG operations since September 2013 while Verizon has done little to mitigate this interference.

By way of background, ABC is licensed to operate fixed and mobile TV pickup stations for ENG within a 120.7-kilometer radius of the Empire State Building in the 2025 - 2110 MHz band.[3] It maintains nine central receive sites within this radius and a fleet of remote trucks that operate throughout the licensed area to cover breaking news events. The New York City Metropolitan Area Frequency Coordinating Committee coordinates routine operations in Broadcast Auxiliary Service ("BAS") bands including the 2025 - 2110 MHz band and has

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[1] The station address and contact person with regard to this informal complaint are: Kurt Hanson, Vice President and Director of Engineering, WABC, 7 Lincoln Square, New York, NY 10023; (917) 260-7201.

[2] All factual matters referenced in this informal complaint are supported by the declaration of Kurt Hanson, Vice President and Director of Engineering of WABC, attached hereto as Exhibit A.

[3] ABC holds licenses for BAS stations KA40716, WLP704, WLD705 and KS2169.

assigned BAS Channel A7 (2097.5-2109.5 MHz) to WABC for its day-to-day newsgathering operations.

Verizon is authorized to provide AWS to the public in Cellular Market Area #1, New York, NY-NJ/Nassau-Suffolk ("New York Market") in AWS Channel Block A (2110-2120 MHz for base station transmit/downlink, 1710-1720 MHz for mobile station transmit/uplink).[4] Verizon also is authorized to operate in AWS Channel Block B (2120-2130 MHz downlink, 1720-1730 MHz uplink) over a similar area. Verizon has aggregated Channel Blocks A and B together in the New York Market to create a single, 20 MHz AWS channel spanning 2110-2130 MHz.

Recognizing that AWS Channel Block A operations would cause interference to incumbent BAS operators, prior to issuing any licenses for AWS Channel Blocks A and B, the FCC established rules that obligate AWS licensees to "protect previously licensed Broadcast Auxiliary Service (BAS) . . . operations in the adjacent 2025-2110 MHz band."[5] These rules also require AWS licenses to coordinate the location of any base or fixed station operating in the 2100-2155 MHz band with BAS licensees operating in the adjacent 2025-2110 MHz band prior to constructing and operating any AWS base or fixed station.[6] The FCC rules further obligate AWS licensees to implement technical solutions as necessary to minimize interference, including the installation of filters in AWS transmitters.[7]

Verizon acquired 2 GHz AWS licenses in the New York metropolitan area from T-Mobile in October 2012.[8] ABC understands that Verizon began rolling out commercial AWS in the New York Market using this spectrum sometime in 2013. Despite its clear obligation to do so under Section 27.1133 of the Commission's rules, Verizon did not coordinate the construction and operation of its AWS base and fixed stations with WABC in the New York Market prior to deployment of these stations. Moreover, ABC understands that Verizon is continuing to deploy its "XLTE" network using AWS Channel Blocks A and B without the prior coordination required by the FCC's rules. Due, in part, to this lack of prior notice and coordination, WABC began experiencing increased levels of interference to all of its ENG central receive sites around September 1, 2013. WABC immediately alerted Verizon to this condition. Using procedures developed by Vcomm (Verizon's consultant), tests were conducted on September 25, 2013, in Asbury Park, New Jersey. The tests showed that OOBE from Verizon AWS sites are a principal source of interference to WABC's ENG operations. Vcomm provided a report of the test results to both Verizon and WABC and, based on these tests, Verizon put out a request for proposals for high-power, temperature stable notch filters that would suppress OOBE from AWS transmitters and thereby mitigate interference to ENG receivers but continued its AWS operations.

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[4] WQGB263 and WQGA906, both licensed to Cellco Partnership dba Verizon Wireless.

[5] 47 C.F.R. § 27.1133. *See also* Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands, Report and Order, 18 FCC Rcd 25162, ¶¶ 129-130 (2003), modified by Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands, Order on Reconsideration, 20 FCC Rcd 14058 (2005).

[6] *See id.*

[7] *Id.*

[8] *See* FCC File No. 0005272654 and Memorandum Opinion and Order and Declaratory Ruling, FCC 12-95 (rel. Aug. 23, 2012).

Verizon claims that it subsequently installed notch filter-pairs at those AWS sites that, in its judgment, were most likely to cause interference to ABC's ENG central receive sites based on distance and orientation (direction) of the AWS transmitting antenna. Although the installation by Verizon of transmit notch filters mitigated the level of interference and degradation at a few of the WABC ENG central receive sites, these sites nonetheless have remained unusable for all but the strongest ENG transmissions due to OOBE from unfiltered AWS sites.

As a result of the continuing and widespread nature of the ongoing interference from Verizon's AWS operations and Verizon's failure to acknowledge responsibility for timely taking action to eliminate the interference, in November 2014, WABC arranged various on-site measurements and observations at AWS and ENG sites pursuant to an agreed upon joint test plan with WABC, Verizon, the FCC's New York Enforcement Bureau Field Office, and the National Association of Broadcasters ("NAB"). The measurements taken in late November 2014 of the ENG band took into account Verizon's limited installation of notch filters, both while the Verizon AWS sites were operating normally and while the AWS sites were largely shut-down.[9] OOBE from the Verizon sites was clearly observed when comparing these two sets of measurements. In addition, WABC observed that while the Verizon sites were shut down, ABC's central receive sites at Alpine, New Jersey and 4 Times Square were able to receive a signal by microwave feed from a camera operating on Channel A7 in Asbury Park, New Jersey. Conversely, when Verizon's AWS sites were operational, these links were completely unusable due to interference.

Section 27.1133 obligates Verizon to protect BAS operations from interference and to coordinate interference protection prior to deployment of its AWS stations. Nevertheless, despite the unequivocal evidence of interference to WABC's operations caused by Verizon's AWS operations that were identified in September 2013 and verified again in the joint engineering test in November 2014[10] and despite ABC's repeated attempts to work with Verizon on this matter, to date Verizon has failed to take the necessary actions to timely remedy the interference it causes to all ABC ENG operations in the New York metropolitan area. Rather, Verizon has indicated only that it intends to install filters on AWS stations within close proximity of ABC's nine central ENG sites. Importantly, Verizon has not provided any comprehensive plan or timetable for resolving all interference to WABC's ENG operations, including the fleet of remote trucks that WABC operates throughout the licensed area to cover breaking news events. Rather, despite the clear AWS-to-BAS interference caused by Verizon's operations throughout the New York Market, Verizon continues to deploy new AWS LTE sites throughout WABC's licensed service area, with no notification to, or prior coordination with, WABC as required by Section 27.1133.

For the reasons stated above, ABC requests that the Enforcement Bureau find that Verizon is in violation of Section 27.1133 of the Commission's rules and require that Verizon install ENG notch filters at all current and future Verizon AWS base station sites using Channel Blocks A and B located within 36 miles of each fixed ENG site used to support WABC's broadcast operations. Unless and until Verizon fulfills this requirement, ABC respectfully

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[9] *See* Report of Robert D. Weller, P.E., National Association of Broadcasters, Interference to 2 GHz ENG From Advance Wireless Services: New York City (Dec. 17, 2014), attached hereto as Exhibit B ("*Interference Report*")

[10] *See Interference Report*, 15-16.

requests that Verizon immediately be required to cease deployment of new AWS LTE sites within WABC's licensed service area and either cease existing operations or eliminate interference through reduced bandwidth operation at each AWS site that requires filters to eliminate existing interference to WABC's ENG operations.

Respectfully submitted,

Tom W. Davidson
Akin Gump Strauss Hauer & Feld, LLP
1333 New Hampshire Ave., NW
Washington, DC 20036
Counsel for American Broadcast Companies, Inc.

Kurt Hanson
Vice President and Director of Engineering
WABC-TV
7 Lincoln Square
New York, NY 10023

EXHIBIT A

DECLARATION OF KURT HANSON

DECLARATION OF KURT J. HANSON

I, Kurt J. Hanson, hereby declare, under the penalty of perjury, that the foregoing is true and correct, to the best of knowledge, information, and belief:

1. I am Vice President & Director of Engineering, WABC-TV, New York, New York ("WABC"). I am responsible for the technical and engineering operations of WABC, including technical matters relating to WABC's electronic news gathering ("ENG") operations using frequencies in the 2 GHz band.

2. Around September 1, 2013, WABC first began experiencing increased levels of interference to all of its ENG central receive sites and determined, through tests conducted at that time, that out-of-band emissions ("OOBE") from Verizon's Advanced Wireless Services sites are a principal source of interference to WABC's ENG operations.

3. Since September 2013, I have made repeated attempts to work with Verizon to resolve the OOBE interference but, to date, Verizon has not provided any comprehensive plan or timetable for resolving all interference to WABC's ENG operations. Thus, as of the date hereof, WABC continues to experience OOBE interference from Verizon's operations.

4. I have reviewed the instant informal complaint and, as to factual matters (whether or not expressly covered by this declaration), the information set forth therein is true and accurate to the best of my knowledge and belief.

Kurt J. Hanson

February 27, 2015

EXHIBIT B

INTERFERENCE REPORT

DECEMBER 17, 2014

INTERFERENCE TO 2 GHZ ENG FROM ADVANCED WIRELESS SERVICES

NEW YORK CITY

ROBERT D. WELLER, P.E.
Vice President for Spectrum Policy
Office of strategic Planning
NATIONAL ASSOCIATION OF BROADCASTERS
1771 N Street, NW ▪ Washington, DC 20036

NAB™
NATIONAL ASSOCIATION OF BROADCASTERS

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Executive Summary

Measurements were taken and observations were made at electronic newsgathering (ENG) central receive sites operated by American Broadcasting Companies, Inc., licensee of WABC-TV, New York, New York, to determine whether out-of-band emissions (OOBE) from the Advanced Wireless Service (AWS) operations of Verizon Wireless are causing interference and/or degrading ENG operations.

Comparative measurements taken at one ENG central receive site, first with the AWS system operating normally and then with most of the AWS transmitters within 50 miles turned off, indicate that OOBE from AWS operations in the A and B frequency blocks (2110-2130 MHz) fall within ENG Channel A7 (2097.5-2109.5 MHz) and interfere with ENG operations. Degradation varied with antenna azimuth from 5 to 20 dB. Measured levels of OOBE from AWS operations at a second ENG site also varied with azimuth and resulted in degradation of 15 to 30 dB. Harmful interference from AWS OOBE was observed at two additional ENG central receive sites that prevented reception of video transmissions when the AWS system was operating normally.

Verizon Wireless failed to coordinate its planned construction and operation of AWS stations as required and as a result widespread interference from AWS to ENG blankets the New York City metropolitan area. Verizon Wireless has installed notch filters at some of its AWS transmit sites, apparently on a case-by-case basis. Those filters appear to be effective in reducing OOBE in ENG Channel A7 to levels at which degradation and interference at ENG central receive sites are substantially eliminated. Based on the measurements taken and other data, it is recommended that notch filters be installed at all AWS base station sites using Channel Blocks A and B within 59 kilometers (36 miles) of each ENG central receive site using Channel A7. ABC operates nine such sites in the New York City area to support the operation of its broadcast television station, WABC-TV. Additional filters may also be needed to protect temporary fixed and portable ENG operations. The number of affected Verizon Wireless AWS base station facilities is not known.

Background Information

Electronic Newsgathering (ENG). Most electronic newsgathering by television stations is accomplished using microwave transmission in the 2 GHz broadcast auxiliary services (BAS) spectrum, which includes eight 12-MHz wide channels between 2025 and 2110 MHz. Electronic newsgathering is typified by a "remote truck" feeding video from the location of a breaking news story to a central receive site located atop a tall building some distance away. Temporary fixed and portable operations are also commonly used for ENG. As shown in Figure 1, American Broadcasting Companies, Inc. (ABC) is licensed[1] to operate fixed and mobile TV pickup stations for ENG within a 120.7-kilometer radius of the Empire State Building in the 2025 to 2110 MHz BAS spectrum. It maintains nine central receive sites within this radius, and a fleet of remote trucks that are deployed to cover breaking news events. See Appendix C for details. The New York City Metropolitan Area Frequency Coordinating Committee coordinates routine operations in BAS bands and has assigned BAS Channel A7 (2097.5-2109.5 MHz) to WABC-TV for its day-to-day newsgathering operations. All of the other channels in that band are similarly assigned to other television stations and networks, and are not available for day-to-day use by ABC.

Figure 1. 120.7-kilometer authorized service area for KA40176.

[1] FCC License KA40716.

Advanced Wireless Services (AWS). AWS operations are typified by a large number of base stations (called enhanced Node B or eNodeB) having antennas located atop buildings of moderate height, each of which provides two-way wireless data services to users over a limited radius (a few city blocks in an urban area such as New York City) surrounding each site. Verizon Wireless is authorized[2] to provide Advanced Wireless Services to the public in Cellular Market Area #1 (New York, NY-NJ/Nassau-Suffolk) in AWS Channel Block A (2110-2120 MHz base station transmit/downlink, 1710-1720 MHz mobile station transmit/uplink). Verizon Wireless is also authorized to operate in AWS Channel Block B (2120-2130 MHz downlink, 1720-1730 MHz uplink) over a similar area. In the New York City area, Verizon has bonded Channel Blocks A and B together to create a single, 20 MHz AWS channel spanning 2110-2130 MHz.

History of interference. Interference to ENG operations from AWS has a fairly long history. As shown in Figure 2, BAS Channel A7 is adjacent to AWS downlink Block A, so interference to BAS receivers may occur due to both blocking (also known as "brute force overload" or BFO) and out-of-band emissions (OOBE) from high-power AWS base station transmitters in Channel Block A. Because ENG central receive sites are located at high elevations, which have line-of-sight over large geographic areas, interference to such sites from AWS base station transmitters can occur over large distances. Conversely, interference from BAS to AWS has not been reported because ENG transmitters utilize low power levels and/or highly directional antennas, operate itinerantly and intermittently, and are typically located near ground level with limited line-of-sight to potentially affected AWS mobile receivers.

In 2002 and 2003, as the Federal Communications Commission (FCC) was developing the rules that established AWS, it expressed concern that AWS-to-BAS interference was likely to occur. As a result, the FCC established rules that require AWS licensees to coordinate the location of any base or fixed stations operating in the 2100-2155 MHz band with BAS licensees operating in the adjacent 2025-2110 MHz band, and implement technical solutions as necessary including the installation of filters in AWS transmitters to minimize interference.[3] See Appendix B.

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2 WQGB263 and WQGA906, both licensed to Cellco Partnership dba Verizon Wireless.

3 See 47 CFR §27.1133. See also, Report and Order, WT Docket 02-353, "Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands," at ¶129-130.

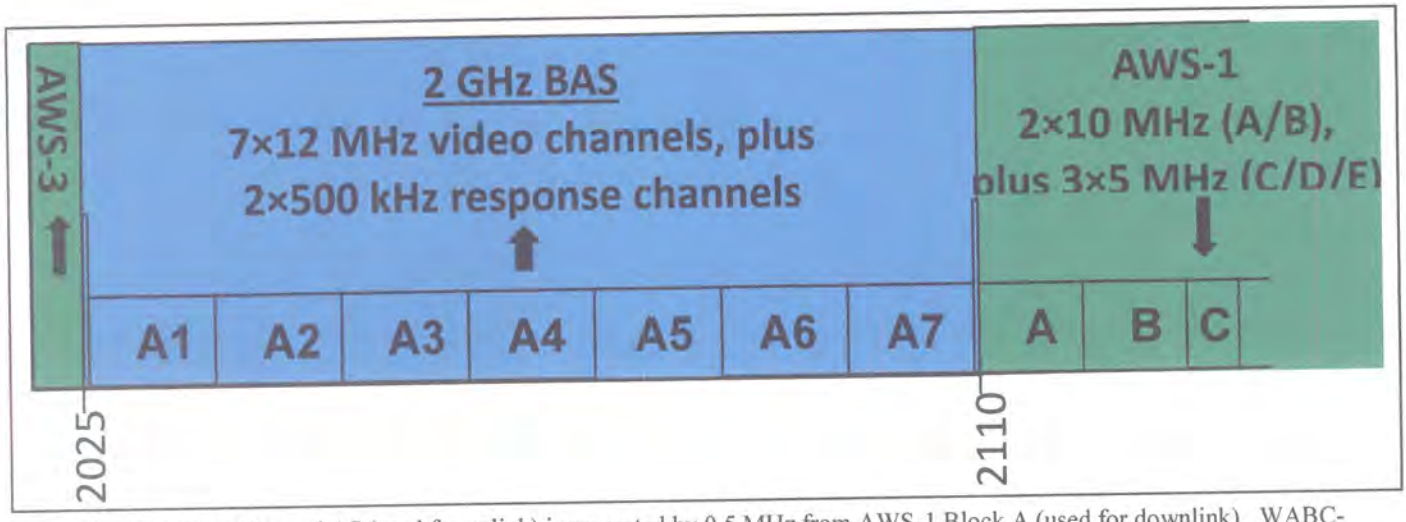

Figure 2. BAS Channel A7 (used for uplink) is separated by 0.5 MHz from AWS-1 Block A (used for downlink). WABC-TV operates on Channel A7 (2097.5 – 2109.5 MHz). Verizon Wireless operates in Blocks A and B (2110 – 2130 MHz).

Interference in New York City. By 2006, manufacturers of AWS transmitting equipment began on-air testing that resulted in interference to BAS users in the New York City area.[4] Also in 2006, the AWS spectrum was auctioned by the FCC, and T-Mobile USA was the successful bidder for AWS Channel Block A in a number of markets, including the New York City market. As T-Mobile built out its AWS network in that market, it coordinated with ABC and other entities to avoid interference to ENG operations, and ultimately provided receive bandpass filters to ABC, which mitigated interference due to brute-force overload to ENG central receive sites. T-Mobile also took a number of additional, internal network actions to mitigate OOBE interference at ENG central receive sites, including limiting use of AWS Channel Block A and shifting its transmit frequency away from the ENG spectrum. The additional actions taken by T-Mobile were enabled, in part, by its choice to deploy so-called "3G" technologies, such as HSPA+, in the AWS band.

In 2013, T-Mobile USA and Verizon Wireless agreed to exchange 2 GHz AWS licenses for 700 MHz licenses and other considerations,[5] [6] which gave Verizon Wireless control of AWS Channel Block A in the New York City market. Since acquiring 2 GHz AWS spectrum, Verizon has not coordinated its planned AWS operations with BAS users as required, and is presently continuing to deploy its "XLTE" network using AWS Channel Blocks A and B; LTE is a so-called "4G" technology.[7] Because of the way that Verizon has designed its AWS system, bonding AWS Channel Blocks A and B to create a

4 http://www.tvtechnology.com/feature-box/0124/new-aws-band-reject-filter-developed/201952
5 http://www.bloomberg.com/news/2014-01-06/t-mobile-to-buy-wireless-spectrum-from-verizon-for-2-4-billion.html
6 http://www.fiercewireless.com/story/verizon-wireless-swap-aws-pcs-spectrum-t-mobile/2013-12-18
7 http://www.pcmag.com/article2/0,2817,2458251,00.asp

single 20 MHz channel block, it is not practical to limit use of AWS Channel Block A or shift its transmit frequency away from the adjacent ENG spectrum. As observed during these tests, OOBE from Verizon's AWS 4G transmitters were found to cause interference to 2 GHz ENG systems that did not occur from T-Mobile's AWS 3G transmitters.

Indeed, ABC began experiencing dramatically increased interference to all of its ENG central receive sites around September 1, 2013 and immediately alerted Verizon Wireless to the condition. A test was conducted[8] that demonstrated that OOBE from Verizon Wireless AWS sites are a principal source of interference. As a result, Verizon put out a request for proposals for high-power, temperature stable notch filters that would suppress OOBE from AWS transmitters and thereby mitigate interference to ENG receivers. Because the Verizon LTE system is 2-layer MIMO,[9] two transmitters are used for each antenna sector and two transmit notch filters are required for each antenna sector (one for each transmitter). Verizon indicates that it has installed these notch filter-pairs at those AWS sites, which in its judgment are most likely to cause interference to ABC's ENG central receive sites based on distance and orientation (direction) of the AWS transmitting antenna. For example, Verizon may determine that it is necessary to filter only one antenna sector of an AWS site having three antenna sectors located one mile from an ENG receive site because the other two antenna sectors are not oriented toward the ENG site. This approach ignores reflections of AWS signals from buildings, which are also capable of causing interference and occur frequently in dense urban areas. ABC has reported that the installation by Verizon of transmit notch filters mitigated the level of interference and degradation at some of the ABC ENG central receive sites, but they nonetheless remain unusable for all but the strongest ENG transmissions due to OOBE from unfiltered AWS sites.

On November 19, 20, and 21, 2014, various on-site measurements and observations were made at AWS and ENG sites to ascertain whether Verizon Wireless operations were continuing to degrade or cause interference to the ENG operations of ABC in the New York City area. Prior to conducting the on-site measurements, there were a number of e-mail exchanges and conference calls including representatives from WABC-TV, Verizon Wireless, the FCC New York Field Office, and NAB. A test plan was agreed upon with all parties participating. See Appendix A.

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8 On September 25, 2013, in Asbury Park, New Jersey.

9 Multiple input, multiple output utilizing two independent transmit antennas.

Measurements at AWS Sites

On-site measurements were taken and observations were made at two Verizon Wireless AWS sites to ascertain typical power levels and OOBE levels. Measurements were made at: 1) 37 West 57th Avenue and 2) the J.P. Morgan Building, 383 Madison Avenue (both in the borough of Manhattan). The principal instruments used were a Rohde & Schwarz Type FSH8 spectrum analyzer (owned by ABC) and a Tektronix Type H600 spectrum analyzer (owned by the FCC).[10] An API Technologies Type CMF905 bandpass filter[11] was used to reduce the level of energy in the AWS band so that the OOBE energy could be observed on the FSH8.

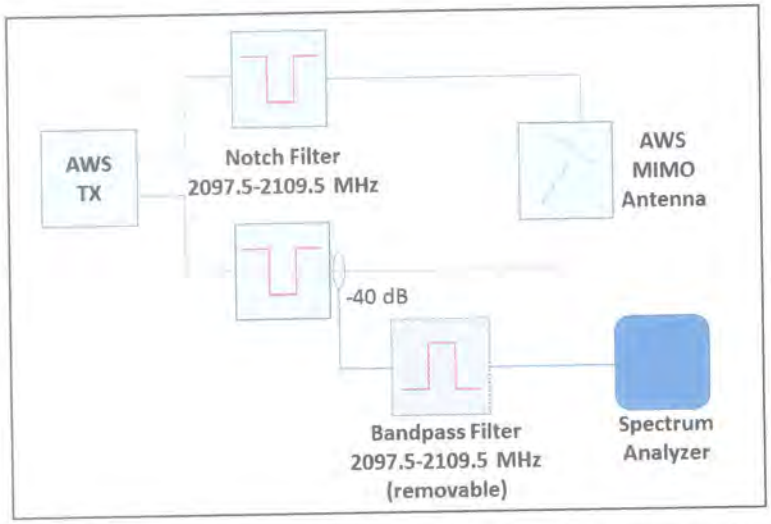

Figure 3. Equipment layout at 37 West 57th Street AWS site. Note that the actual coupling factor is -40.2 dB.

37 W 57th Ave. Measurements and observations were made on November 19, 2014, beginning at about noon at the Verizon Wireless AWS site located at 37 West 57th Avenue. One antenna sector was directly accessible from the rooftop, and included a pair of KMW Type KFTDRAW74001 transmit notch filters and an Amphenol (Antel) Type BXA-171063/8CFEDIN transmit antenna.[12] A coupler on the output of one of the notch filters was used for all measurements. The spectrum analyzers showed that the power in the AWS band (2110-2130 MHz) varied considerably due to traffic variation at the site, as is typical of LTE transmissions. The "max hold" feature of the Tektronix spectrum analyzer was therefore used to capture the highest power level during the observation period. The observed power level at 2115

10 An Anritsu spectrum analyzer, owned by Verizon Wireless, was also available.

11 Estimated insertion loss 0.6 dB at 2097 MHz; 62 dB or greater above 2110.6 MHz. See http://micro.apitech.com/pdf/cmt/CMF905.pdf

12 http://www.amphenol-antennas.com/getattachment/77bd7bbf-76cb-4eec-8464-c59002e13891/BXA-171063-8CF-EDIN-X.aspx

MHz was -9.1 dBm in 100 kHz bandwidth.[13] Correcting approximately for the bandwidth of the AWS signal ($10\times\log_{10}$ (20 MHz/100 kHz) or 23 dB), the coupling factor (40.2 dB), and cable and connector losses (estimated to be 1 dB) yields the power input to the antenna as -9.1 + 23 + 40.2 + 1 = 55.1 dBm. The typical peak to average power ratio (PAPR) for LTE OFDM signals is about 9.2 dB (0.01% time),[14] so the average power input to the antenna is estimated to be 55.1 – 9.2 = 45.9 dBm or 38.9 watts. Verizon reported that the nominal power output for this transmitter is 40 watts, so the measured result appears consistent with expectations.

The CMF905 filter was then inserted between the antenna and the spectrum analyzer. The observed level of OOBE in the ENG band at 2109.2 MHz was -59.29 dBm in 100 kHz bandwidth.[15] Correcting approximately for the coupling factor (40.2 dB), cable and connector losses (2 dB), and filter insertion loss (1.5 dB) yields the OOBE power input to the antenna as -59.29 + 40.2 + 2 + 1.5 = -15.59 dBm. The PAPR associated with OOBE and the transmission line loss from the AWS transmitter are undocumented so no adjustment for those factors are made. The OOBE limit specified in FCC rules is -16 dBm (200 kHz bandwidth, equivalent to -19 dBm in 100 kHz bandwidth) measured at the transmitter output, so compliance with FCC requirements depends on the PAPR characteristics of the OOBE.

J.P. Morgan. Measurements and observations were also made on November 19, 2014, beginning at about 2:45 pm at the Verizon Wireless AWS site located at J.P. Morgan Building (383 Madison Avenue). The antennas were not accessible, so measurements were made at the transmitter. Three transmitters, Alcatel-Lucent Type TRDU2x60-AWS, each having two output ports, were rack-mounted at this site. One transmitter-pair included a pair of KMW Type KFTDRAW74001 transmit notch filters. TX1 of this transmitter pair was selected for measurement. A monitor port having a coupling factor of -42.09 dB was available on this transmitter. The average channel power (2108-2132 MHz) was measured as 4.84 dBm using the channel power measurement capability of the spectrum analyzer.[16]

Correcting for the coupling factor (42.09 dB) and cable and connector losses (estimated to be 1 dB) yields the power output from the transmitter as 4.84 + 42.09 + 1 = 47.93 dBm or 62 watts. Verizon reported that the nominal power output for this transmitter is 60 watts, so the measured result is consistent with expectations.

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13 See FCC capture 01118-2.png, 11/14/2014, 12:28 pm.
14 See Alcatel-Lucent Type AS5BBTRX-13 transmitter test report, Appendix C.
15 See FCC capture 01119-5.png, 11/19/2014, 12:39 pm.
16 See NAB Photo IMG_1151.jpg 11/19.2014, 3:21 pm.

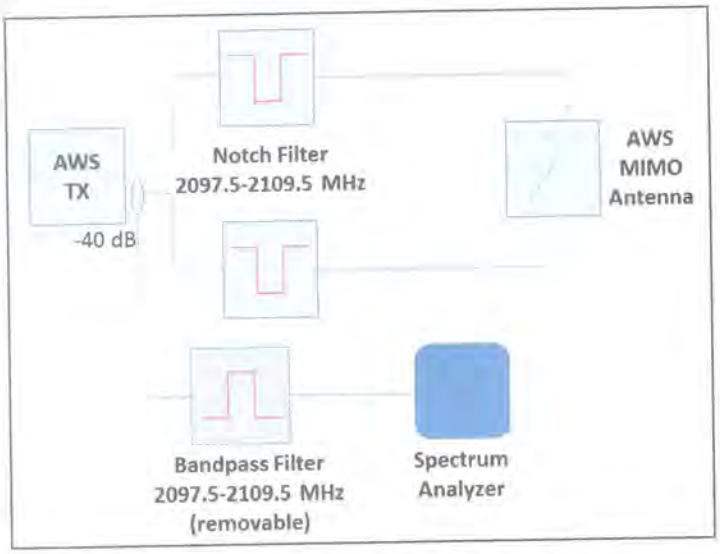

Figure 4. Equipment layout at 383 Madison Avenue AWS site. Note that the actual coupling factor is 42.09 dB.

Prior to the above AWS on-channel power measurement, the CMA905 filter was inserted between the transmitter and the spectrum analyzer. The observed level of OOBE at 2109.2 MHz was -66.01 dBm in 100 kHz bandwidth.[17] Correcting approximately for the coupling factor (42.09 dB), cable and connector losses (estimated to be 2 dB), and filter insertion loss (1.5 dB) yields the OOBE power at the output of the transmitter as -66.01 + 42.09 + 2 + 1.5 = -20.42 dBm. The PAPR associated with OOBE is undocumented so no adjustment for that factor is made. The OOBE limit specified in FCC rules is -16 dBm (200 kHz bandwidth, equivalent to -19 dBm in 100 kHz bandwidth) measured at the transmitter output, so compliance with FCC requirements depends on PAPR characteristics of the OOBE.

Subsequent to the on-channel power measurement, the CMA905 bandpass filter was inserted between the output port of the KMW notch filter and the spectrum analyzer. The observed level of OOBE at 2109.2 MHz was -75.4 dBm in 100 kHz bandwidth.[18] Correcting approximately for the coupling factor of the KMW notch filter (40.5 dB), cable and connector losses (estimated to be 1 dB), and filter insertion loss (1.5 dB) yields the OOBE power at the output of the filter as -75.4 + 40.5 + 1 + 1.5 = -32.4 dBm. The PAPR associated with OOBE is undocumented so no adjustment for that factor is made. Thus, the KMW notch filter reduces the level of OOBE by at least 32.4 – 20.42 = 11.98 dB. Typical filter performance (See Appendix D) indicates that reductions in OOBE on the order of 37 dB can be expected at frequencies below 2109.5 MHz.

[17] See FCC Capture 1119-22.png, 11/19/2014, 3:06 pm.
[18] See FCC Capture 1119-31.png, 11/19/2014, 3:45 pm.

Measurements at ENG Sites

On-site measurements were taken and observations were made at two ABC ENG central receive sites to document levels of undesired energy (interference) falling in BAS Channel A7. The measurement sites were the Millenium Building and Citigroup Plaza, both located in borough of Manhattan. The principal instruments used were a Rohde & Schwarz Type FSH8 spectrum analyzer (owned by ABC) and a Tektronix Type H600 spectrum analyzer (owned by the FCC).[19] Firmware Type FSH-K50 allowed the FSH8 to measure operational characteristics of 3GPP LTE (FDD) AWS transmissions, including the locally-unique physical cell identity associated with the Verizon Wireless eNodeB facilities (base stations).

Nucomm "Newscaster" Model CR7 ENG receivers were installed at both sites, and both utilized NSI "Superquad" antennas. The NSI antenna is a radome-enclosed, offset-feed parabolic "dish," which is steerable in azimuth by remote control. Published gain at 2 – 2.5 GHz is 25 dBi and azimuth beamwidth (-3 dB) is 8 degrees. The NSI antenna enclosure includes a low-noise amplifier (LNA) with adjustable gain. An API Technologies Type CMA806 bandpass filter[20] is permanently installed at the ENG site and is used to reduce the level of energy in the AWS band so that receiver blocking does not occur. The API filter can be switched in and out to allow measurements in the AWS band. The NSI antenna enclosure also includes a preselector (integral bandpass filter) that rolls off at frequencies above 2110 MHz. The estimated attenuation of the NSI preselector in the AWS band at 2112 MHz is 2.5 dB, 10.5 dB at 2114 MHz, increasing to 30 dB or more at 2120 MHz. This preselector cannot be switched out. Therefore, measurements in the AWS band were confined to frequencies as close as possible to 2110 MHz. A line diagram of the ENG central receive sites is shown in Figure 5.

[19] An Anritsu spectrum analyzer, owned by Verizon was also available.

[20] Estimated insertion loss 2.2 dB at 2109 MHz; 60 dB or greater rejection above 2110.6 MHz. See http://micro.apitech.com/pdf/cmt/cma806.pdf

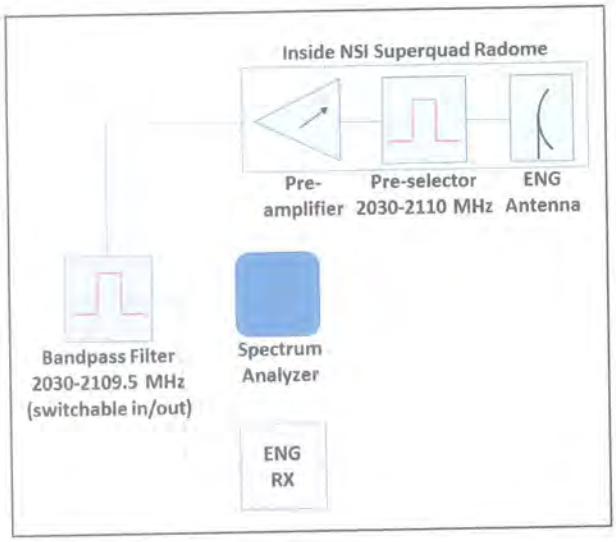

Figure 5. Equipment layout at ENG sites.

Citicorp Plaza (AWS In-Service only). On November 20, beginning at about 1:00 pm, at the Citigroup Plaza site, measurements were made using the FSH8, while the NSI antenna was rotated in 5° increments from 0° TN (true North) to 355° TN while the level of observed energy in the AWS band at approximately 2112 MHz was recorded. The API filter was switched out during these measurements. Then, measurements were similarly taken in the ENG band with the API filter switched in. The displayed averaged noise level of the spectrum analyzer in 100 kHz bandwidth with no signal present was about -106 dBm or less. Observed levels in the AWS band ranged from -31 to -41 dBm. Correcting approximately for filter losses at 2112 MHz (2.5 dB), these levels are approximately -28.5 to -38.5 dBm. Observed levels in the ENG band ranged from -79 to -91 dBm with the API filter in. All of these values are 5 dB or more above the displayed average noise level (DANL) of the spectrum analyzer, which indicates that at every azimuth, there is degraded performance of the ENG system ranging from 15 dB to over 30 dB. An example of the noise observed in the ENG band is shown in Figure 6.

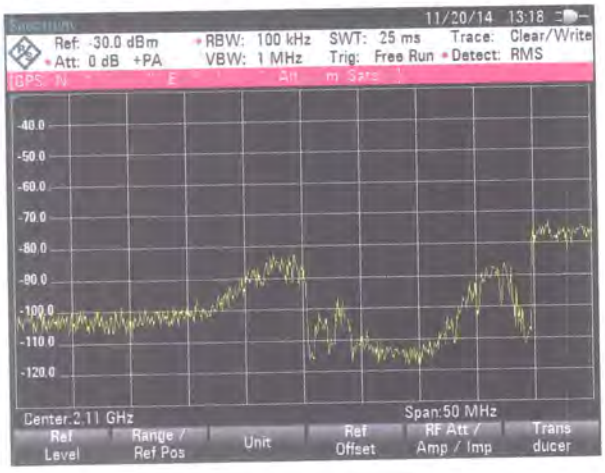

Figure 6. Observed noise in ENG band at Citicorp site. Azimuth 115°T. The peak noise just below 2110 MHz is about -82 dBm, which is 24 dB above the DANL at 2080 MHz. The sloping shape of the noise is indicative of OOBE from an AWS transmitter. (FCC capture BPM0073, 11/20/2014, 13:18).

Millennium Building (AWS In and Out of Service). On November 21, beginning at about 10:40 pm, at the Millennium Building site, measurements were made using the FSH8, while the NSI antenna was rotated in 5° increments from 0° TN (true North) to 355° TN while the level of observed energy in the AWS band at approximately 2112 MHz was recorded. The API bandpass filter was switched out during these measurements. Then, measurements were taken similarly in the ENG band with the API filter switched in. The displayed averaged noise level of the spectrum analyzer in 100 kHz bandwidth with no signal present was about -106 dBm or less. Observed levels in the AWS band ranged from -36 to -51 dBm. Correcting approximately for filter losses at 2112 MHz (2.5 dB), these levels are approximately -33.5 to -48.5 dBm. Observed levels in the ENG band ranged from -87 to -101 dBm with the filter in. All of these values are 5 dB or more above the DANL indicating that at every azimuth, there is degraded performance of the ENG system of at least 5 dB, in some cases approaching 20 dB.

On November 22, beginning at midnight, Verizon Wireless began a systematic shutdown of all of its AWS sites within about 50 miles of Manhattan. The shutdown was largely complete by 1:00 am, although a few AWS sites could not be controlled remotely and so were not shut down. While the Verizon sites were shut down, measurements were again made using the FSH8 while the NSI antenna was rotated in 5° increments from 0° TN (true North) to 355° TN and the level of observed energy in the ENG band was recorded. The API bandpass filter was switched in during these measurements.

While the OOBE energy from AWS sites is known to vary with time, the measurements in the ENG band taken while the Verizon AWS sites were operating normally were compared with those taken while the AWS sites were largely shut-down.[21] OOBE from the Verizon Wireless sites were clearly observed in these comparative measurements. An example of the difference between noise levels with and without the AWS sites operating is shown in Figure 7. The yellow trace is with the AWS sites operating normally, while the red trace is with them not operating. An increase in the noise floor of more than 10 dB in BAS Channel A7 is apparent (the yellow hump just below 2110 MHz).

[21] In addition to the AWS OOBE, an unknown, presumably local (to the Millenium site) noise source was observed in the band 2100-2110 MHz over the arc 20°-180°T. This noise was not observed at the other ENG central receive sites.

Figure 7. Comparative noise in ENG band at Millennium site. Azimuth 270°T. The noise peak just below 2110 MHz is about -92 dBm, which is 15 dB above the DANL. The noise was confirmed by on/off testing to be OOBE from an AWS transmitter. (FCC captures BPM0250, 11/20/2014, 23:09 and BPM395 11/21/2014, 01:52).

Interference at Two Other ENG Sites

ABC operates a camera in Asbury Park, New Jersey, which can be fed by microwave on Channel A7[22] to the central receive sites. While the Verizon Wireless AWS network was turned off on the morning November 21, the Asbury Park signal was observed at WABC-TV master control. It was usable at the central receive sites at Alpine, New Jersey and 4 Times Square. However, when the AWS network was operating normally (before and after the shutdown), the link was unusable due to interference at those sites.

[22] FCC license WLP705.

Recommended Protection Requirement for ENG

Interference protection criteria for digital microwave services have been developed based on limiting degradation of performance due to interfering signals to a designated percentage of the overall degradation allowance.[23] The degradation allowance is determined with respect to the system noise floor, N, measured at the receiver. In particular, the ITU recommends that interference, I, from other fixed-service systems should not exceed an I/N of -6 dB for more than 20% of any month, while interference from other primary allocated services should not exceed an I/N of -10 dB for more than 20% of any month. Similarly, for digital mobile systems, an I/N of -6 dB is also appropriate.[24] An I/N of -6 dB corresponds to an increase in system noise of 1 dB, while an I/N of -10 dB corresponds to an increase in system noise of about 0.4 dB.[25] Thus, protection of an ENG receiver requires that the OOBE from an AWS fall at least 6 dB below the system noise level measured at the receiver.

Based upon theory and measurement data supplied by ABC (see Appendix D), it is estimated that the system noise level of the ENG central receive system located at the Millennium site is about -98 dBm. The error-free sensitivity of the CR7/NSI ENG systems (with the NSI preamplier) is -83 dBm in the normal operating mode (16QAM, COFDM, FEC 3/4, 8 MHz BW). The normal mode of operation requires a C/N ratio of about 15 dB for error-free operation.[26] Measurements by ABC indicate that the preamplifier has a noise figure of 3 dB. So, the noise floor at the CR7 receiver is -83 – 15 = -98 dBm. Therefore, OOBE levels at the ENG receiver should not exceed -98 dBm – 6 dB = -104 dBm to satisfy the -6 dB I/N protection criterion.

Estimated Extent of AWS Interference

FCC equipment authorization data (Appendix C) and field measurements indicate that a 20 MHz AWS carrier places slightly less than -16 dBm/MHz in the spectrum 2104.5 – 2109.5, which comprises the upper portion of BAS Channel A7. Taking the level to be -17 dBm and the bandwidth to be 5 MHz, the total power is -17 dBm + $10\times\log_{10}(5)$ = -10 dBm in BAS Channel A7. The slope of the OOBE and the emissions falling below 2104.5 MHz (also falling in Channel A7) are neglected for simplicity, so

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23 NTIA Report 05-432, "Interference Protection Criteria," p. 4-3.
24 *Ibid* p. 7-1
25 *Ibid* p. 4-5
26 http://www.teamcast.com/data/upload/files/dvb_t_t2_fundamentals_1SHctF.pdf

-10 dBm is taken to be the total out-of-band emission (OOBE) power produced by the AWS transmitter that falls within ENG receiver passband. Assuming 1 dB of loss between the AWS transmitter and the transmit antenna and assuming the gain of the AWS antenna to be 17.4 dBi (see Appendix D), the EIRP of that OOBE is

$$\text{EIRP} = -10 \text{ dBm} - 1 \text{ dB} + 17.4 \text{ dBi} = +6.4 \text{ dBm}$$

Assuming that the AWS and ENG the antennas are "bore-sighted," the maximum received signal level (RSL) at the BAS receiver can be calculated as a function of free space path loss (FSPL) between the AWS and BAS antennas given the EIRP and BAS receive station parameters. Free space path loss is conventionally defined as

$$\text{FSPL} = 20\times\log_{10}(\text{d, in kilometers}) + 20\times\log_{10}(\text{f, in MHz}) + 32.45$$

Taking the frequency to be 2100 MHz, the BAS antenna gain to be 25 dBi (see Appendix D) and assuming 1 dB of loss in the ENG system, the RSL can be calculated from

$$\text{RSL} = +6.4 \text{ dBm} - [20\times\log_{10}(\text{d, kilometers}) + 98.89] + 25 \text{ dBi} - 1 \text{ dB}$$

For example, a 10 km separation between the AWS transmitter and the ENG receiver would result in an RSL of -88.5 dBm at the ENG receiver. Using the -6 dB I/N protection criterion, an unfiltered AWS transmitter would be expected to impair the sensitivity of an ENG receiver by 1 dB at a distance of up to 59.2 kilometers (36.9 miles).

Thus, all AWS transmitters within 59.2 kilometers should be equipped with ENG notch filters to avoid degrading operations in BAS Channel A7 by more than 1 dB.

Expected Effect of AWS Filter

Verizon reports that it has tested transmit filters from API[27] and KMW.[28] Available information indicates that such filters can provide additional suppression of OOBE of perhaps 39 dB in BAS Channel A7. See Appendix D. While actual performance is likely to vary with temperature, aging, impedance, and other factors, suppression of OOBE by perhaps 35 dB might be expected.

[27] http://micro.apitech.com
[28] http://www.kmw.co.kr/eng/

Using the same analysis as above, the use of an AWS transmit filter should theoretically reduce the OOBE EIRP from the AWS site from -10 dBm to perhaps -45 dBm. This reduction in radiated OOBE would correspondingly reduce the RSL at the ENG receiver and thus dramatically decrease the distance at which an AWS facility is likely to interfere with a BAS receiver.

While interference to temporary fixed and portable ENG operations has also been reported by ABC, the performance of those systems in the presence of AWS signals has not yet been characterized. Nonetheless, the installation AWS transmit notch filters are likely to greatly reduce the potential for interference to those ENG systems as well. Recommendations for specific protection distances from temporary fixed and portable ENG receive antennas are beyond the scope of this report.

Appendix A – Proposed Test Plan

WEDNESDAY, NOVEMBER 19 – Site Visits

09:00 Meet at WABC-TV, 7 Lincoln Square (149 Columbus Avenue, corner of 67th St. and Columbus Avenue). Introductions. View "bench" ENG gear. Inventory available test equipment.

Review installed ENG equipment at Millennium building, 1992 Broadway (nearby). Verify type(s) and performance of installed BAS equipment if possible.

Measure ENG and AWS spectrum at BAS receive site(s), noting azimuths and levels to strongest interference sources. Identify offending site(s) using test equipment if possible.

Use other BAS receive sites to other "DF" location(s) of interference sources, if possible

12:00 Visit Verizon Wireless Site(s), locations at 37 West 57th Avenue and 383 Madison Avenue.

Review installed AWS equipment. Determine equipment and power level(s) in use.

Document performance of transmit filter.

THURSDAY, NOVEMBER 20 – Prep for Measurements

22:30 Meet at WABC-TV.

Set up equipment and document existing conditions at Millenium site.

FRIDAY, NOVEMBER 21 – Overnight Measurements

00:00 Begin shutdown of Verizon AWS Network

Determine whether strongest sources of interference disappear. Conduct measurements to document change in noise floor at ENG site.

Identify remaining interference sources using test equipment or DF techniques, if possible.

03:30 Measurements complete, restore AWS network

Appendix B – Extracts from FCC Rules

AWS

The Advanced Wireless Service (AWS) is generally regulated under Part 27 of FCC Rules. For information, some of the applicable technical rules are copied below:

§27.50 (d) The following power and antenna height requirements apply to stations transmitting in the ... 2110-2155 MHz... bands:

(1) The power of each fixed or base station transmitting in the ... 2110-2155 MHz ... band and located in any county with population density of 100 or fewer persons per square mile, based upon the most recently available population statistics from the Bureau of the Census, is limited to: (i) An equivalent isotropically radiated power (EIRP) of 3280 watts when transmitting with an emission bandwidth of 1 MHz or less; (ii) An EIRP of 3280 watts/MHz when transmitting with an emission bandwidth greater than 1 MHz.

(2) The power of each fixed or base station transmitting in the ... 2110-2155 MHz band and situated in any geographic location other than that described in paragraph (d)(1) of this section is limited to: (i) An equivalent isotropically radiated power (EIRP) of 1640 watts when transmitting with an emission bandwidth of 1 MHz or less; (ii) An EIRP of 1640 watts/MHz when transmitting with an emission bandwidth greater than 1 MHz.

§27.53 (h) *AWS emission limits*—(1) *General protection levels.* ... for operations in the ... 2110-2155 MHz ... band, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least $43 + 10 \log_{10}$ (P) dB....

(3) *Measurement procedure.* (i) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.... [However, per KDB 662911 D01 and D02 for the 2-layer MIMO mode, the FCC limit of -13 dBm shall be 3 dB more stringent. Therefore all channel edge and out of band spurious emissions shall be -16 dBm or less.]

§27.1133 Protection of Part 74 and Part 78 Operations. AWS operators must protect previously licensed Broadcast Auxiliary Service (BAS) or Cable Television Radio Service (CARS) operations in the adjacent 2025-2110 MHz band. In satisfying this requirement AWS licensees must, before constructing and operating any base or fixed station, determine the location and licensee of all BAS or CARS stations authorized in their area of operation, and coordinate their planned stations with those licensees. In the event that mutually satisfactory coordination agreements cannot be reached, licensees may seek the assistance of the Commission, and the Commission may, at its discretion, impose requirements on one or both parties.

BAS

The broadcast auxiliary service (BAS) is generally regulated under Part 74 of FCC rules. For information, some of the applicable technical rules are copied below:

§74.601 (a) *TV pickup stations.* A land mobile station used for the transmission of TV program material and related communications from scenes of events occurring at points removed from TV station studios to a TV broadcast, Class A TV or low power TV station....

74.632 (c) An application for a new TV pickup station shall designate the TV broadcast station with which it is to be operated and specify the area in which the proposed operation is intended. The maximum permissible area of operation will generally be that of a standard metropolitan area, unless a special showing is made that a larger area is necessary.

74.636 (a) On any authorized frequency, transmitter peak output power and the average power delivered to an antenna in this service must be the minimum amount of power necessary to carry out the communications desired and shall not exceed the values listed in the following table. Application of this principle includes, but is not to be limited to, requiring a licensee who replaces one or more of its antennas with larger antennas to reduce its antenna input power by an amount appropriate to compensate for the increased primary lobe gain of the replacement antenna(s). In no event shall the average equivalent isotropically radiated power (EIRP), as referenced to an isotropic radiator, exceed the values specified in the following table. ...

Frequency band (MHz)	Maximum allowable transmitter power	Maximum allowable EIRP	
	Mobile (W)	Fixed (dBW)	Mobile (dBW)
2,025 to 2,110	12.0	+45	+35

Appendix C – Extracts from FCC Authorizations

Extract of BAS License Data (WABC-TV, Not a complete list)

Callsign	MHz	TX Lat	TX Long	RX Lat	RX Long	TX	RX	EIRP
WLP704	2097.5-2109.5	40-51-18	072-46-09	40-45-23	73-42-55	Manorville	N. Shore	68.3 dBm
WLP705	2097.5-2109.5	40-13-43	73-59-54	40-45-22	73-59-11	Asbury Park	4 Times Square	67.9 dBm
KA40716	2025.5-2109.5	120.7 km	Around	40-44-54	73-59-09	Radius	(Empire)	63.0 dBm

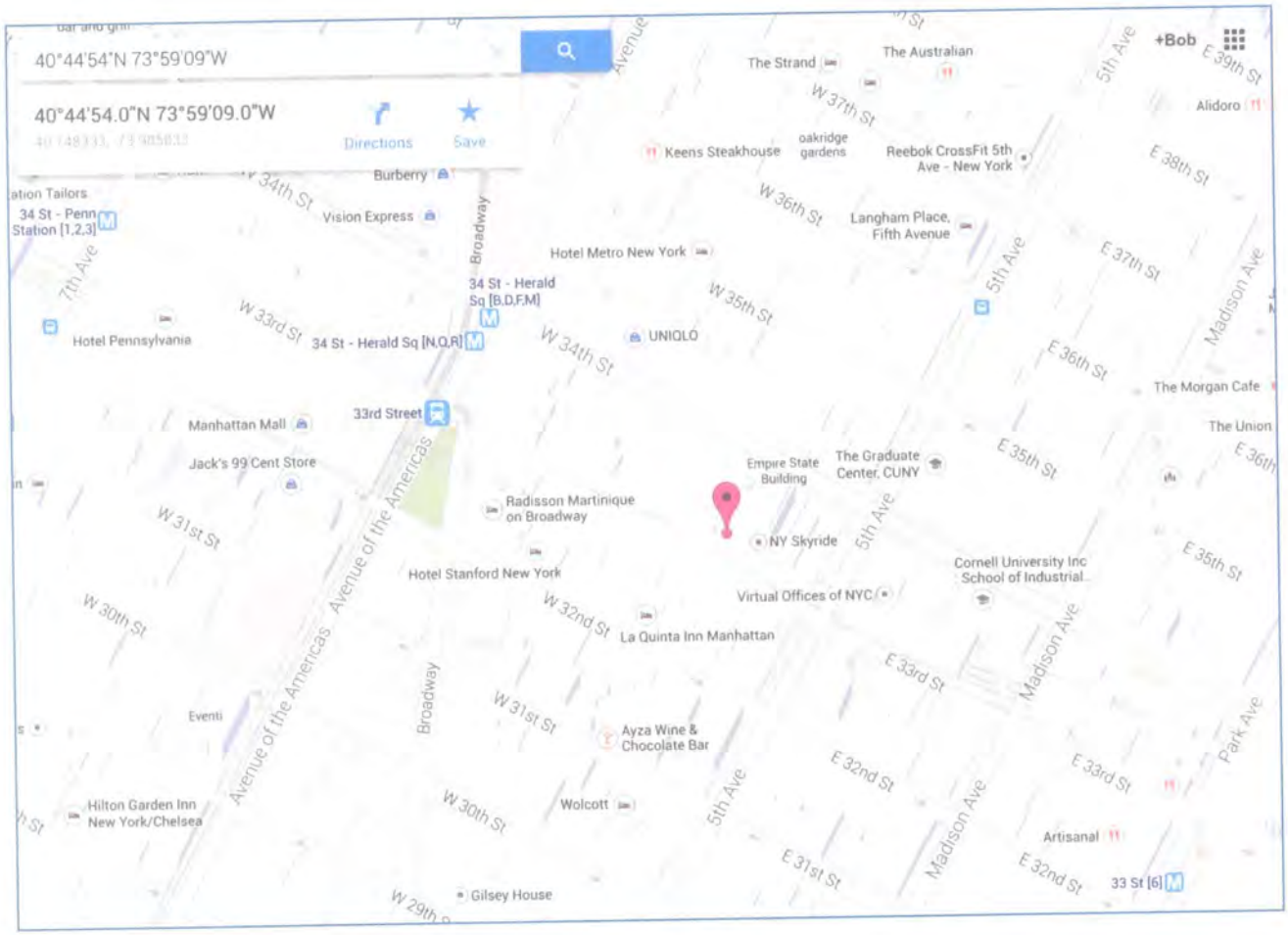


Figure C1. Center of operation for KA40716.

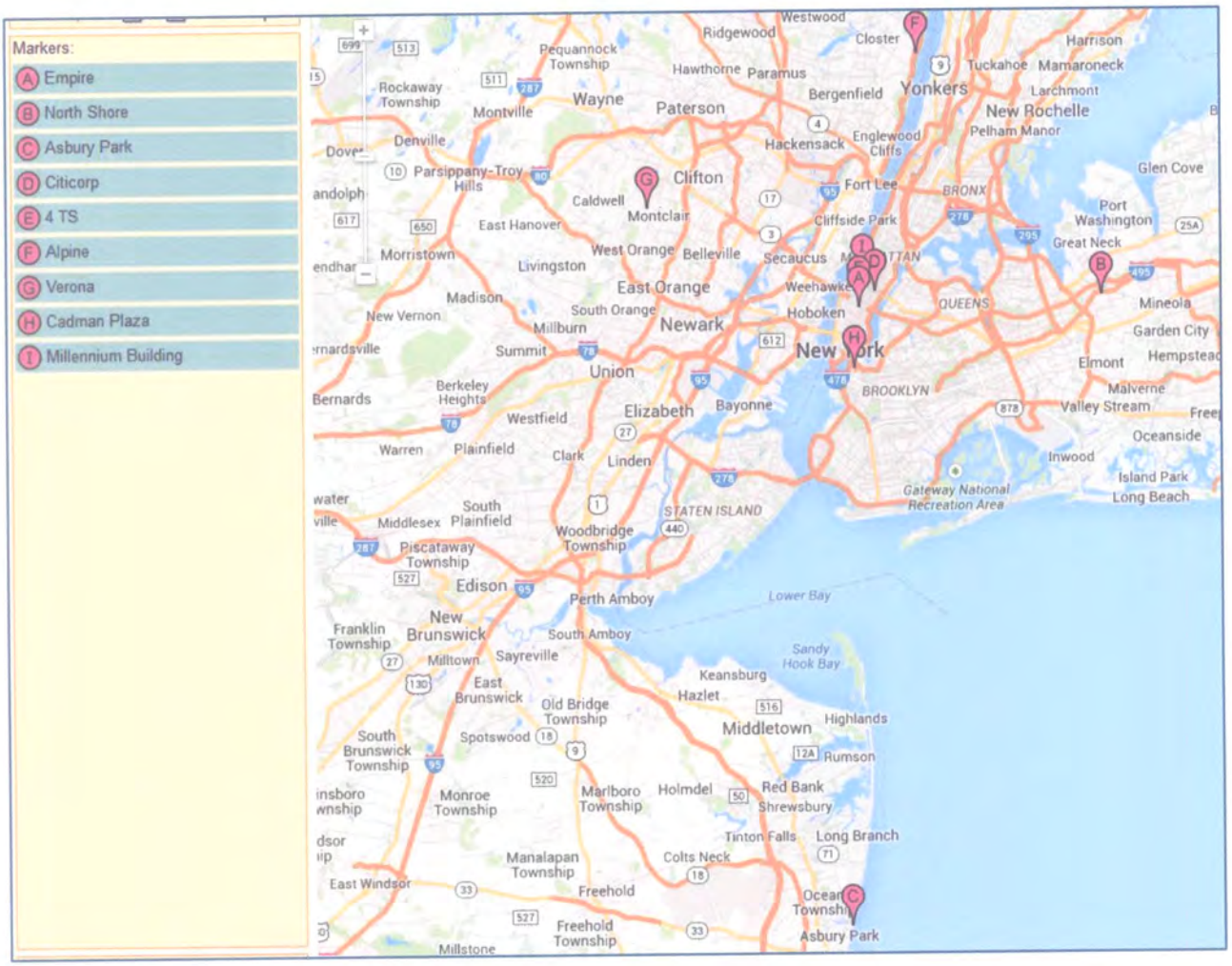


Figure C2. Map showing nine existing WABC-TV 2 GHz Central Receive Sites in New York City area.

Extract of FCC Equipment Authorization AS5BBTRX-13 (Alcatel-Lucent AWS Transmitter TRDU2X60-AWS)

The specific models of all AWS transmitters used by Verizon Wireless in the New York City area are not known, but at Verizon Site No. 58LS (383 Madison Avenue), TRDU2 transmitters were installed. This model is available is available in 40- and 60-watt configurations and supports 20 MHz LTE transmission in Blocks A and B, which is the typical Verizon Wireless configuration in the New York City area.

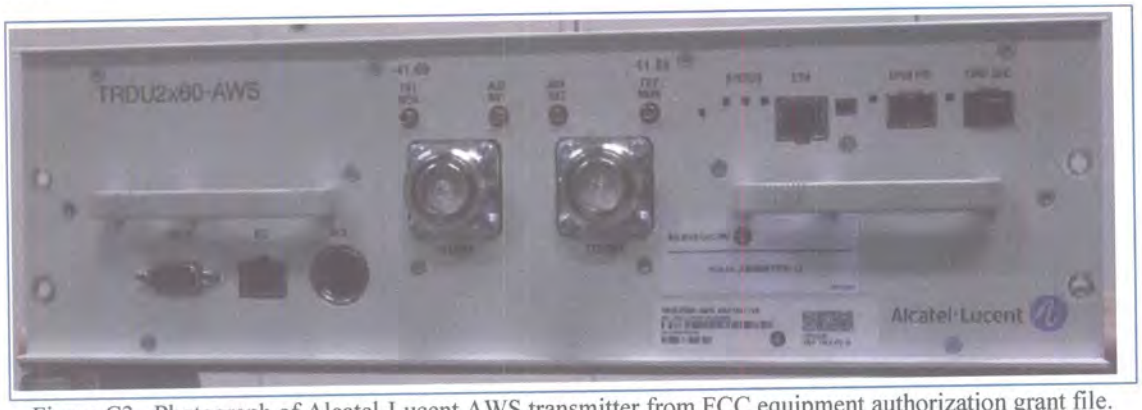


Figure C3. Photograph of Alcatel-Lucent AWS transmitter from FCC equipment authorization grant file.

According to the FCC grant, this Alcatel-Lucent transmitter is authorized for up to 60 watts power output in the frequency range 2110-2155 MHz with authorized emissions up to 18M8F9W. Frequency tolerance is 0.05 ppm. For the grant, the transmitter was evaluated in QPSK, 16QAM, and 64QAM modes. Applicable extracts from the grant documentation are given below.

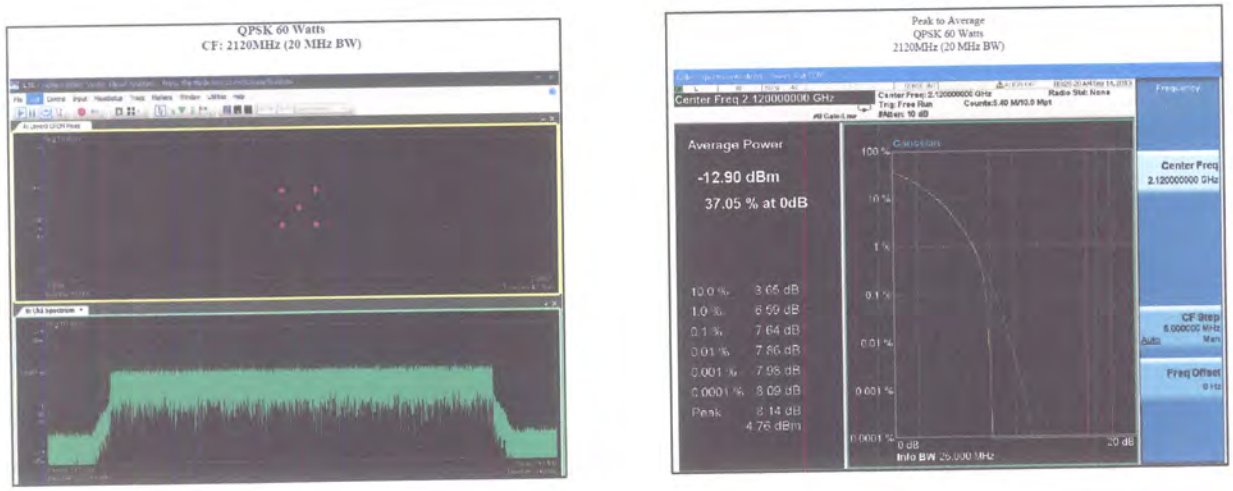


Figure C4. 20 MHz QPSK constellation, spectrum, and peak-to-average power ratio.
(16 QAM and 64 QAM are similar)

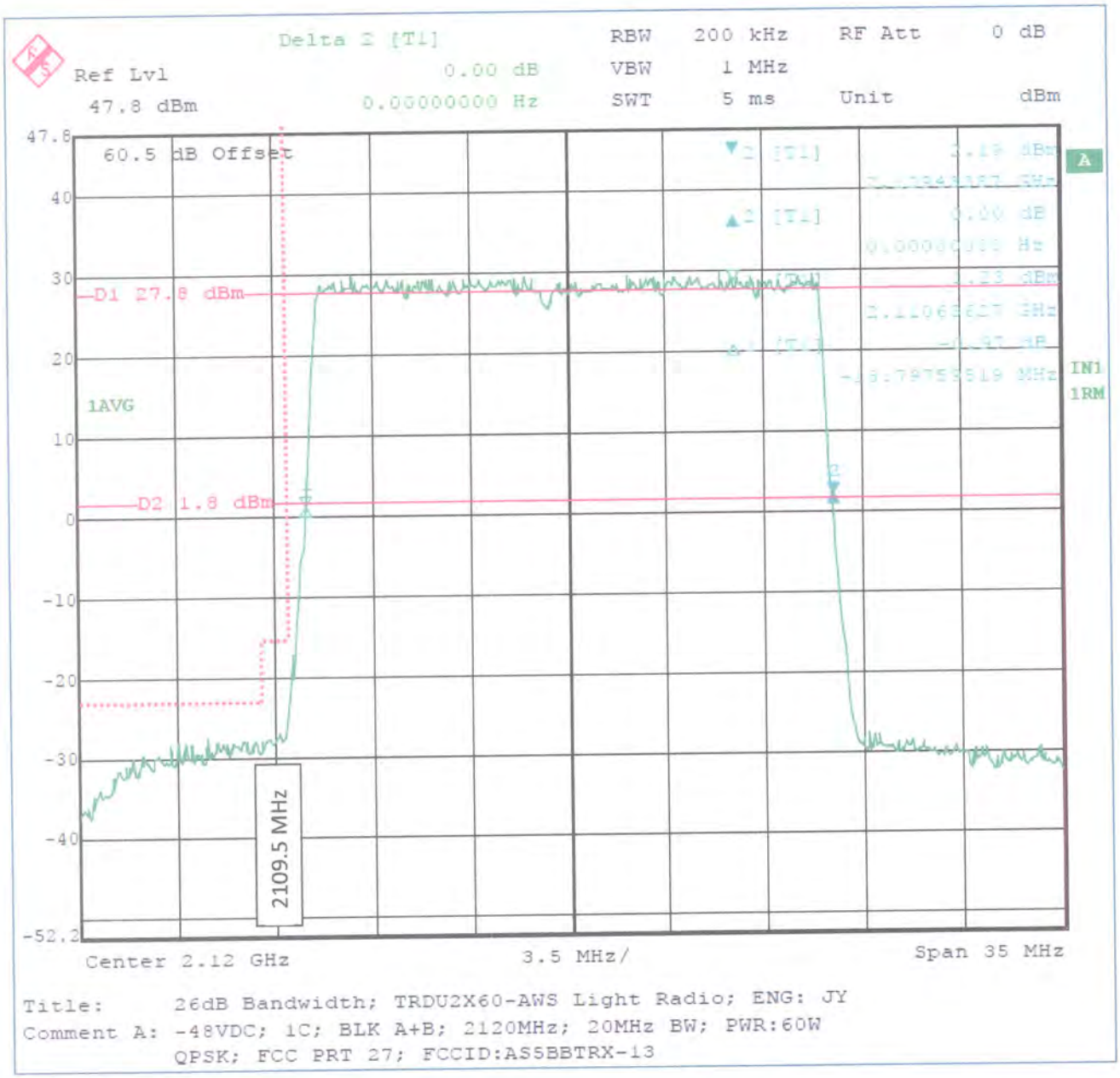


Figure C5. -26 dB Bandwidth of 20 MHz QPSK constellation (16QAM and 64QAM are similar). The resolution bandwidth of the spectrum plot is 200 kHz. The reference level, 47.8 dBm, equals 60 watts total power in 20 MHz. The FCC out-of-band emission mask is shown as a dashed orange line. The nominal limit is -13 dBm at the edge of the authorized channel. Because this is a MIMO system, however, the FCC conducted emission limit at 2109-2110 MHz is tightened by 3 dB to -16 dBm in 200 kHz. At 2109 MHz and below, the FCC limit is -16 dBm in 1 MHz, which is equivalent to -23 dBm in 200 kHz. The corresponding OOBE limits on the "high side" of the LTE emission are not shown.

Appendix D – Installed Equipment

AWS Antenna

While there are a wide variety of AWS eNodeB (base station) antennas available for use and selection of a specific model will depend on local factors, the Amphenol Type BXA-171063-8CF was installed at one of the Verizon Wireless sites that was visited. This antenna has the following published specifications:

Parameter	Value
Frequency range	1920 – 2170 MHz
Gain	17.4 dBi
Azimuth beamwidth to -3 dB points	60 degrees
Elevation beamwidth to -3 dB points	7 degrees
Polarization	Dual linear ±45°
Dimensions	48.2 x 6.1 x 4.1 inches (LxWxD)

ENG Notch Filter

Verizon reports that it has tested transmit notch filters from API[29] and KMW.[30] As noted above, KMW filters were observed at both of the AWS sites that were visited. Information provided by ABC and KMW indicates that such filters can provide additional suppression of OOBE of at least 37 dB in BAS Channel A7. See Figures D1 and D2. While actual performance is likely to vary with temperature, aging, impedance, and other factors, suppression of OOBE by perhaps 35 dB might be expected

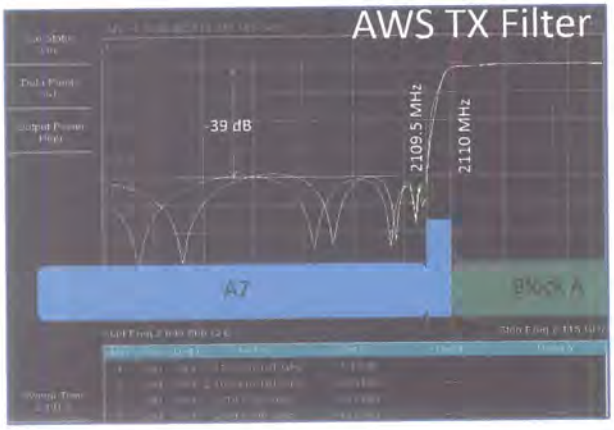
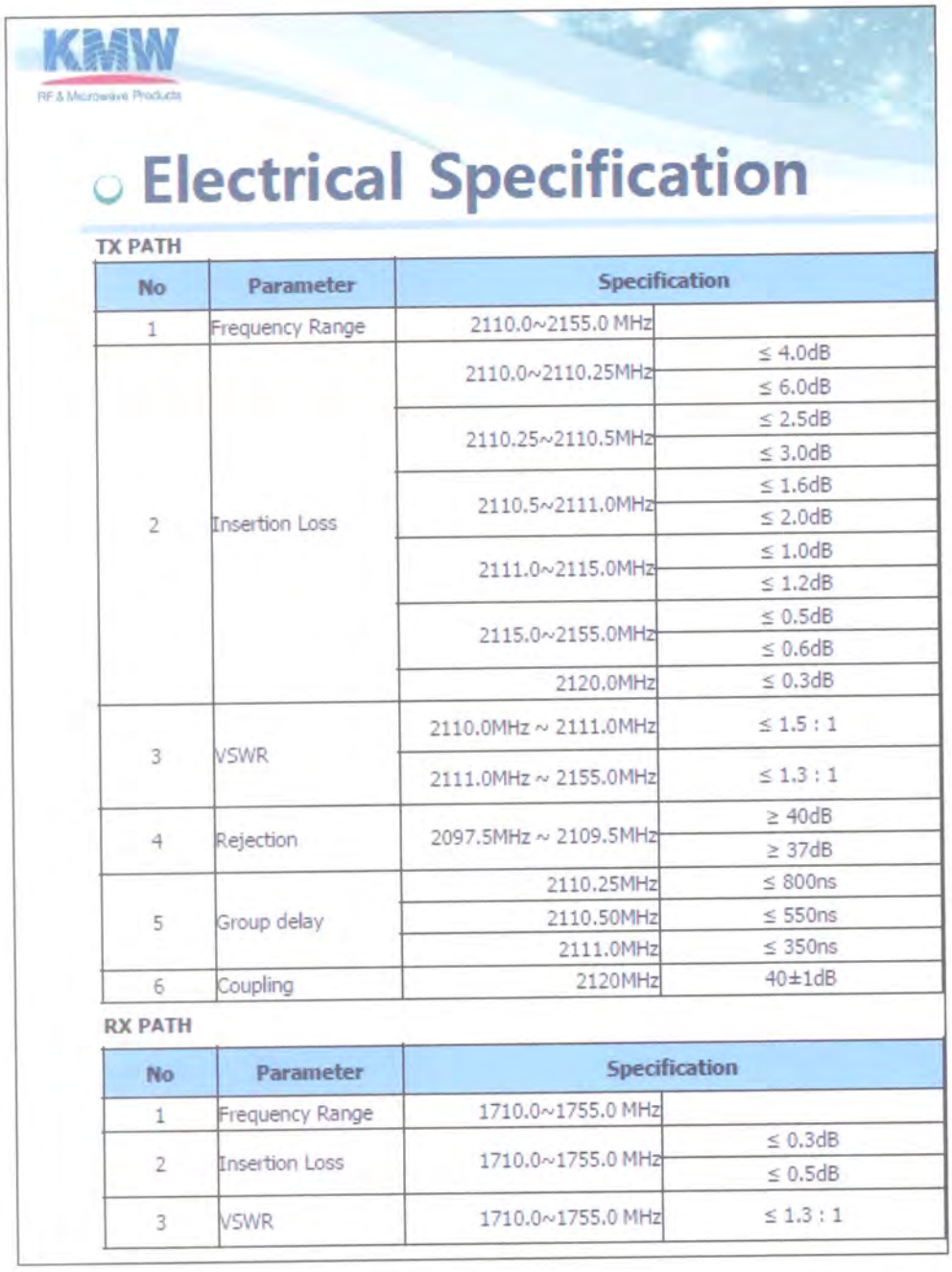


Figure D1. Measured amplitude response of AWS filter (make and model unknown).

29 http://micro.apitech.com
30 http://www.kmw.co.kr/eng/



KMW
RF & Microwave Products

Electrical Specification

TX PATH

No	Parameter	Specification	
1	Frequency Range	2110.0~2155.0 MHz	
2	Insertion Loss	2110.0~2110.25MHz	≤ 4.0dB
			≤ 6.0dB
		2110.25~2110.5MHz	≤ 2.5dB
			≤ 3.0dB
		2110.5~2111.0MHz	≤ 1.6dB
			≤ 2.0dB
		2111.0~2115.0MHz	≤ 1.0dB
			≤ 1.2dB
		2115.0~2155.0MHz	≤ 0.5dB
			≤ 0.6dB
		2120.0MHz	≤ 0.3dB
3	VSWR	2110.0MHz ~ 2111.0MHz	≤ 1.5 : 1
		2111.0MHz ~ 2155.0MHz	≤ 1.3 : 1
4	Rejection	2097.5MHz ~ 2109.5MHz	≥ 40dB
			≥ 37dB
5	Group delay	2110.25MHz	≤ 800ns
		2110.50MHz	≤ 550ns
		2111.0MHz	≤ 350ns
6	Coupling	2120MHz	40±1dB

RX PATH

No	Parameter	Specification	
1	Frequency Range	1710.0~1755.0 MHz	
2	Insertion Loss	1710.0~1755.0 MHz	≤ 0.3dB
			≤ 0.5dB
3	VSWR	1710.0~1755.0 MHz	≤ 1.3 : 1

Figure D2. Cut-sheet for KMW BAS Notch Filter.

ENG Receive Equipment

WABC-TV reports that it uses mostly Nucomm Model CR7 receivers at its ENG central receive sites. A few sites use the Model CR6 and the Empire State Building uses a Microwave Radio Corporation Model MRX4000. The two sites visited use the Nucomm "Newscaster" Model CR7 central receiver, which was selected as representative. The CR7 supports COFDM (DVB-T), 8VSB, and QAM

modulation formats. Depending upon the constellation, data rate and bandwidth, the published threshold sensitivity of the receiver is as follows:

Format	Modulation	Data Rate	Bandwidth	Threshold
2	VSB	9.6 Mbps	6 MHz	-94 dBm
4	VSB	19.4	6	-84
8	VSB	29	6	-77
8T	VSB	19.4	6	-84
COFDM	QPSK 1/2	6.0	8	-93
COFDM	16QAM 1/2	12.1	8	-87 (est)
COFDM	64QAM 1/2	18.1	8	-80 (est)
Analog	FM	--	varies	-87

ABC reports that it typically uses 16QAM, Rate 3/4 COFDM with 8 MHz bandwidth, which results in a measured error-free threshold level of -86 dBm.

At most of its 2 GHz ENG central receive sites, including all of the sites visited, WABC-TV reports that it is using an NSI "Superquad" antenna, shown in Figure D1. The antenna is a radome-enclosed, offset-feed parabolic "dish." It antenna is steerable in azimuth by remote control but has no elevation angle adjustment. The assumed elevation angle is zero (horizontal). Published gain at 2 – 2.5 GHz is 25 dBi. Azimuth beamwidth (-3 dB) is 8 degrees.

ENG Central Receive Antenna

Figure D3. NSI Superquad antenna

The NSI antenna includes a preselector (bandpass filter) and low-noise amplifier (LNA) with adjustable gain. The measured magnitude response of the preselector is shown in Figure D4.

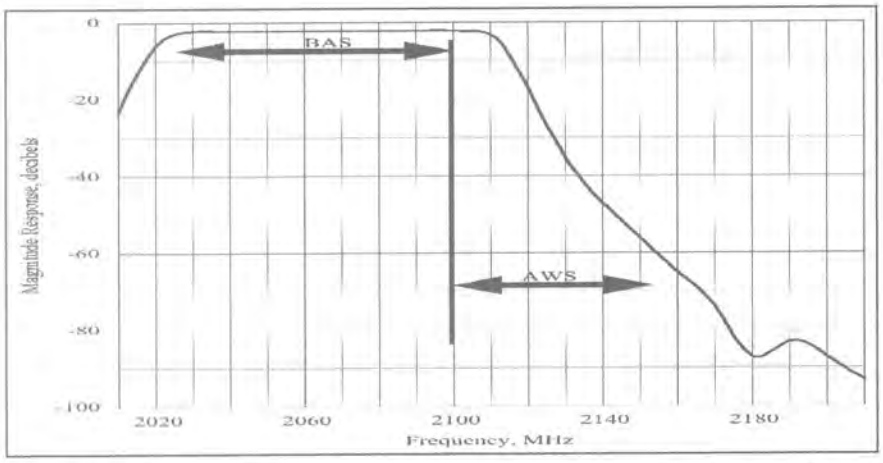


Figure D4. Measured amplitude response of NSI preselector. (Provided by ABC.)